



U.S. DEPARTMENT OF  
**ENERGY**

**Nuclear Energy**



## Fuel Cycle R&D Material Recovery and Waste Form Development Campaign

**Patricia Paviet, Director , Office of Systems  
Engineering and Integration**

**NEUP Webinar  
August 14, 2014**



# Organization Structure

## NE-5

*Deputy Assistant Secretary for Fuel Cycle Technologies:*

*John Herczeg*

*Associate Deputy Assistant Secretary for Fuel Cycle  
Technologies : Andrew Griffith*

**Patricia Paviet**

NE-51

*Systems Engineering  
And Integration*

- **MRWFD(FC-1)**
  - ❖ *Electrochemistry (FC1.1) (S. Kung)*
  - ❖ *Material Recovery (FC-1.2) (J. Bresee)*
  - ❖ *Waste Form (FC1.3) (K. Gray)*
  - ❖ *U from seawater (FC-6) (S. Kung)*
- **Fuel Cycle Options Analysis (FC-5) (K. Kellar)**

**Andrew Griffith**

NE-52

*Fuel Cycle Research and  
Development*

- **Advanced Fuels (FC-2)**
- **Nuclear Materials**
- **Safeguarding and Instrumentation (FC-3)**

**Bill Boyle**

NE-53

*Used Nuclear Fuel  
Disposition Research and  
Development*

- **Used Fuel Storage and Transportation (FC-4.1)**
- **Used Fuel Disposal (FC-4.2)**

**Dave Henderson**

NE-54

*Uranium Management and  
Policy*



# Office of Fuel Cycle Technologies: an Integrated Approach

## Front End



### Uranium Resources

- Conventional production
- Innovative approaches
  - U from Seawater



### Fuel Fabrication

- Safety enhanced LWR fuel
  - Accident tolerance
- Higher performance
  - Improved burnup

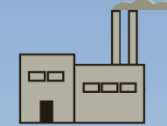


### Reactors



### Interim Storage

- Evaluating extended time frames
- Transport after storage



### Recycle

- Material Recovery
- Recycled fuel
- Secondary waste treatment



### Disposal

- Alternative geologies
- Advanced waste forms

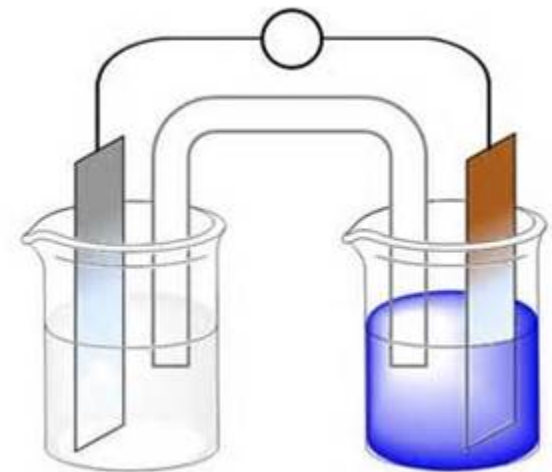
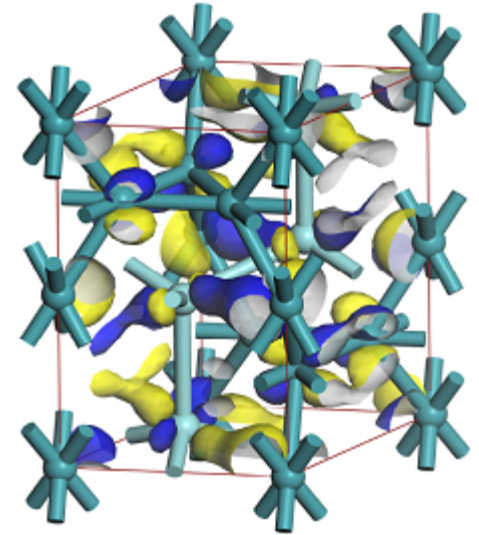
**Optimize through Systems Analysis, Engineering, and Integration**



# Campaign Objective

■ **Develop advanced fuel cycle separation and waste form technologies that improve current fuel cycle performance and enable a sustainable fuel cycle, with minimal processing, waste generation, and potential for material diversion**

- A key sub-objective is to establish collaborative Academic - National Laboratory research programs that provide the next generation of scientists for nuclear science and research that are critical to implementing long term nuclear energy and waste management strategies
- An emphasis is being placed on mentoring early career scientists/engineers to maintain continuity of expertise
- Our job is to develop viable and economic technical options that will inform future decisions on the nuclear fuel cycle

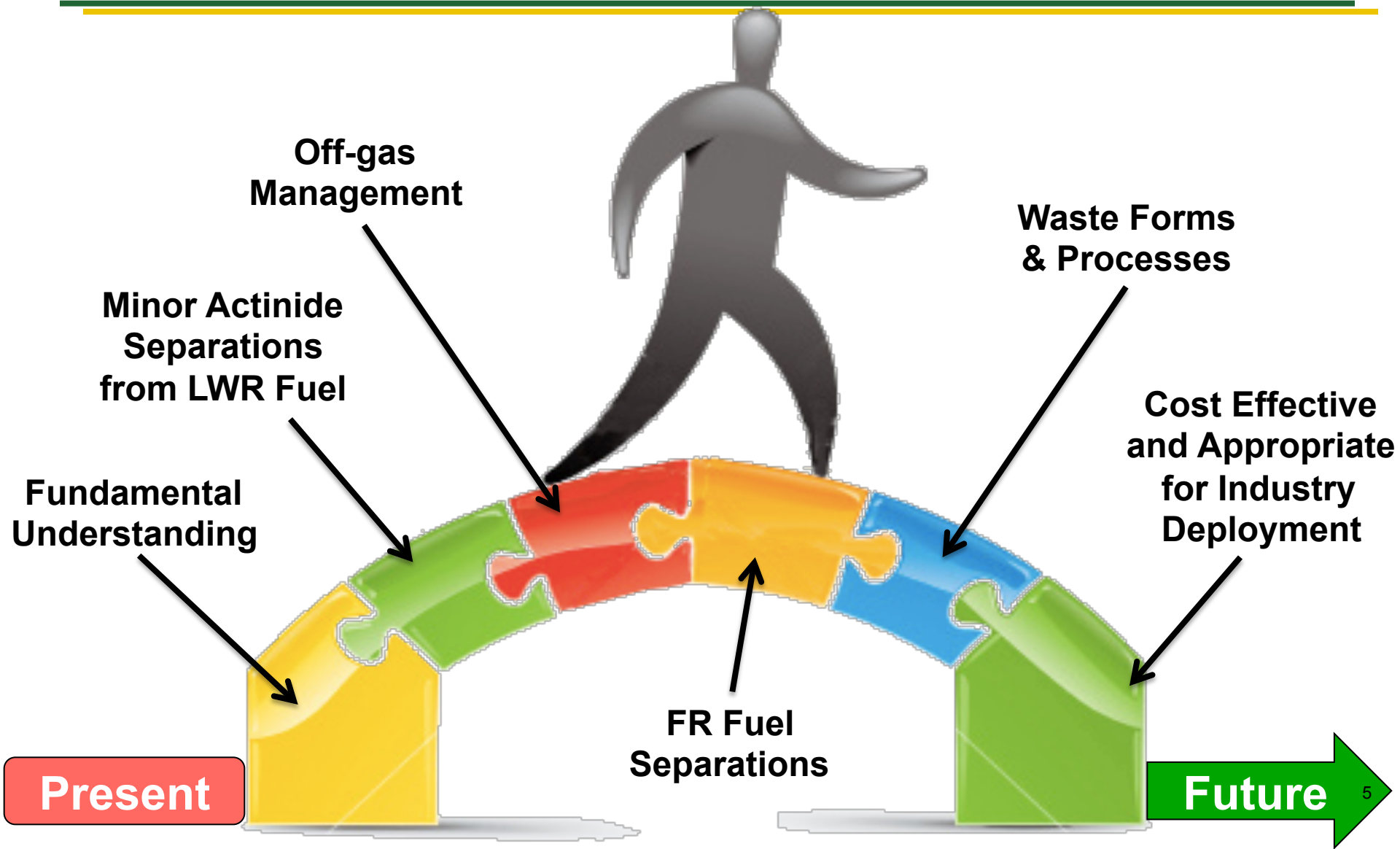




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# Full Recycle Technology Gaps





# Objectives of Major R&D Areas

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### Advanced Aqueous (AA)

- *Develop and demonstrate technologies applicable over a broad range of aqueous separation methods*

### Minor Actinide Sigma Team (MA)

- *Enabling technology for TRU recycle options from LWR fuel*
- *Develop cost effective technology ready for deployment*

### Off-gas Sigma Team (OG)

- *Enabling technology for any recycle option*
- *Develop cost effective technology ready for deployment*

### Fundamental Science / Mod. & Simulation (FS&M, M&S)

- *Develop advanced methods to develop fundamental understanding of separation methods, waste forms, and waste form performance-develop predictive models based on fundamental data*

### Separation Process Alternatives (ASP)

- *Investigate alternative process options to determine if significant cost or performance improvement can be realized*

### Alt. Waste Forms and Characterization (AWF, WFC)

- *Enable broader range of disposal options with higher performance waste forms*
- *Develop cost effective technology ready for deployment*

### Uranium Extraction from Seawater (FR)

- *Develop and demonstrate extractants and engineered systems with increase sorption capacity and selectivity over current technology*

### Electrochemical Processing (DE, JFCS)

- *Develop and demonstrate deployable and sustainable technology for fast reactor fuel recycling*

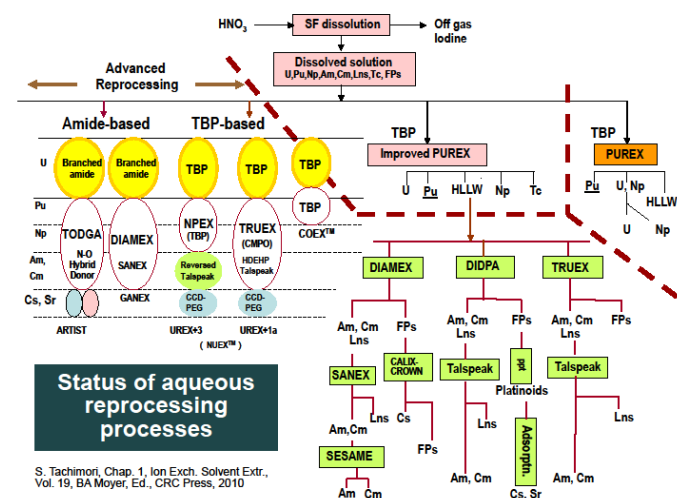


# Campaign Research Needs

## ■ Scientific Bases for Aqueous Separations Processes

Critical gaps exist in our knowledge underlying aqueous separations processes being considered currently for used fuel recycle for the separation minor actinides from lanthanides.

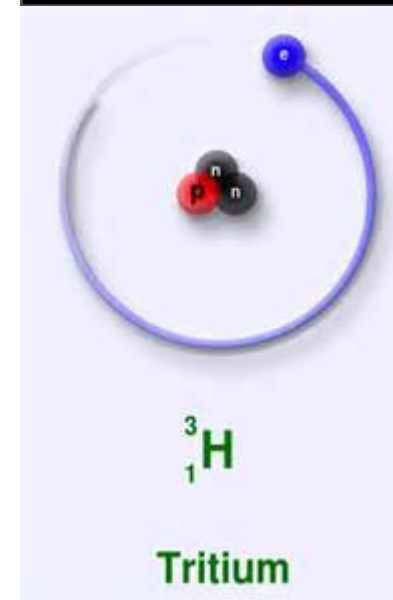
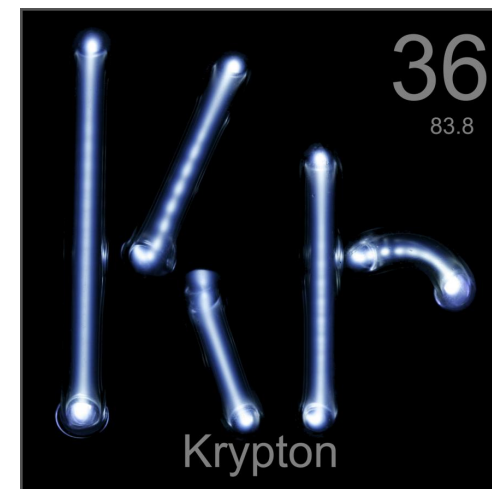
Understanding is generally needed on control of actinide oxidation states, complexation of actinides in aqueous solution, and selectivity of solvent extraction systems for actinides, lanthanides, and fission products. For example, knowledge is very limited regarding redox mechanisms, structure of coordination complexes, and complex speciation in extraction solvents. Research should be directed toward questions dealing with structure, thermodynamics, and kinetics specifically dealing with established or developing process concepts such as ALSEP, SANEX, GANEX, advanced TALSPEAK, or methods making use of the high oxidation states of



# Campaign Research Needs (Cont.)

## ■ Scientific Bases for the capture of volatile off-gas species

Development of new materials for the capture of volatile off-gas species, particularly tritium, iodine and krypton is needed. A fundamental understanding of the mechanisms with which the species is separated along with performance data to allow objective comparison on separation media and methods is desired. Development of models to predict performance of media and separation efficacy is also desired. Research is needed to enable “clean” separation of volatile species, i.e. very low or no cross contamination of species such as iodine and tritium.



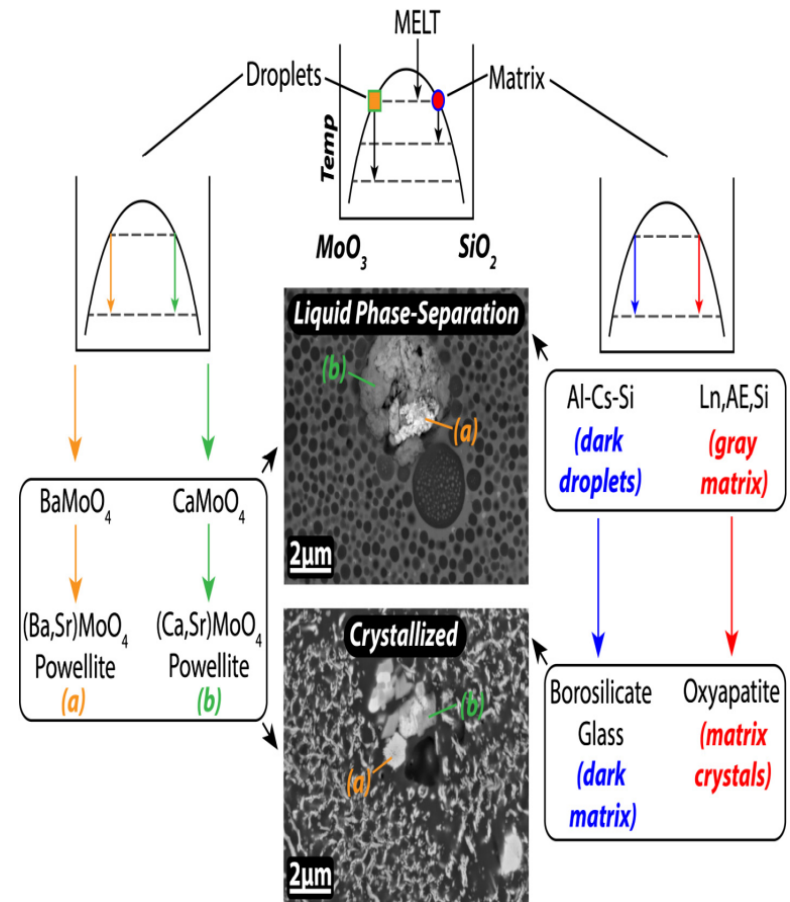




# Campaign Research Needs (Cont.)

## ■ Development, testing, and qualification of an advanced glass ceramics waste form for aqueous processing high-level waste.

Develop a fundamental understanding of the phase transitions leading from melt to multiphase (glass ceramics) waste form as functions of cooling rate and composition. The glass ceramic should be a borosilicate based melt precipitating Powellite, Oxyapatite, and/or lanthanide borosilicates. Cooling rates tested should encompass those expected in full-scale high-level waste glass canisters. This will support the development, testing, and qualification of an advanced glass ceramics waste form for aqueous processing high-level waste.

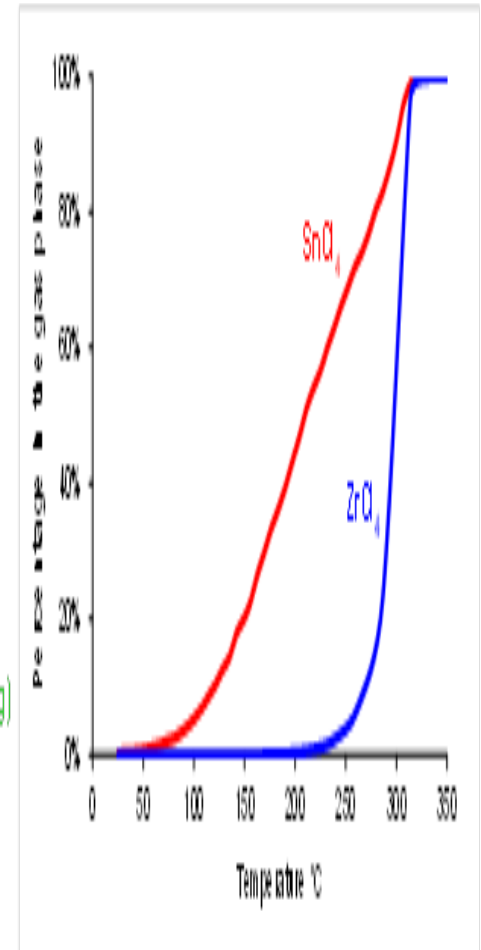
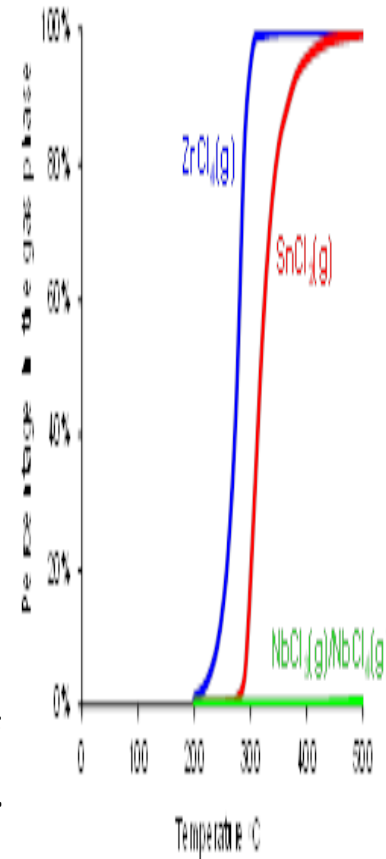




# Campaign Research Needs (Cont.)

## ■ Development of zirconium purification

Investigate the relative volatility at 300-400°C of used nuclear fuel zirconium cladding component chlorides, including alloying agents and residual radionuclides, such as niobium, iron, antimony, and cesium chloride species that are known to have similar volatility to zirconium tetrachloride. This will support the development of zirconium purification from fuel cladding materials which may significantly reduce the amount of highly radioactive waste from fuel processing.





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# Campaign Research Needs (Cont.)

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- **Advanced Electrochemical Separation Technologies (provided by Dr. Stephen Kung)**
- **Uranium from Seawater (provided by Dr. Stephen Kung)**



# Summary

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- The FCR&D Material Recovery and Waste Form Development Program is looking forward to partnering with universities to enhance their R&D portfolio and research capabilities
- This call is tailored to research topics that are well suited for university research
- The MRWFD program seeks university researchers who want to actively participate in the program and enhance interactions with national laboratory research staff
- *The FCR&D Material Recovery and Waste Form Development management team considers NEUP Principal Investigators to be an integral part of our research program!*
  - We encourage and, actively seek close engagement with the MRWFD campaign

